METHOD OF DESIGNING FLOWABLE MORTAR

GENERAL

The design of flowable mortar involves determining the proper proportions to obtain the required flow characteristics.

MATERIALS

Obtain representative samples of the following materials from the producing ready mix plant:

Sand	34 kg (75 lb.)
Portland Cement	7 kg (15 lb.)
Fly Ash	7 kg (15 lb.)

PROCEDURE

A.   Apparatus

    1.   Flow cone and equipment specified in I.M. 375

    2.   Mixer 4.5 L (4 qt.) or larger

    3.   1,000 mL cylinder

    4.   Spatula

    5.   Equipment specified in I.M. 302

    6.   1 mL pipette

B.   Test Samples

    1.   Obtain samples for the sieve analysis and the trial mixes by one of the quartering methods listed in I.M. 302.

    2.   Two samples of at least 4,600 grams should be obtained for the trial mixes. Do not attempt to select a sample of an exact predetermined mass.

C.   Preparation of Samples

   1.   Oven dry the samples to a constant mass and allow to cool. Screen the sample over a 4.75 mm (No. 4) sieve to remove over-sized material.

   2.   Weigh the dry sand samples to the nearest gram and calculate the cement and fly ash batch mass (weight) as follows:

$$\text{Cement Mass} = \text{Sand Mass} \times \frac{(60\,\text{kg/m}^3)}{1550\,\text{kg/m}^3} \qquad \text{Cement Weight} = \text{Sand Weight} \times \frac{(100\,\text{lb./yd.}^3)}{(2600\,\text{lb./yd.}^3)}$$

$$\text{Fly Ash Mass} = \text{Sand Mass} \times \frac{(180\,\text{kg/m}^3)}{1550\,\text{kg/m}^3} \qquad \text{Fly Ash Weight} = \text{Sand Weight} \times \frac{(300\,\text{lb./yd.}^3)}{(2600\,\text{lb./yd.}^3)}$$

Air entraining agent at 38.7 mL/m³ (1 oz./cu. yd.)

$$\text{mL of Air Agent} = \text{Sand Mass} \times \frac{38.7\,\text{mL/m}^3}{1550\,\text{kg/m}^3}$$

$$\text{mL of Air Agent} = \text{Sand Weight} \times \frac{1\,\text{oz./cu. yd.} \times 29.57\,\text{mL/oz.}}{2600\,\text{lb./cu. yd.} \times 453.6\,\text{lb./gm}}$$

D.   Mix Procedure

   1.   Add the air-entraining agent to the mixing water. Add the sand and part of the needed mixing water to the bowl. Start the mixer and add the cement, fly ash, and water. Add water until the mix appears fluid. Mix for three minutes after adding all materials.

   When too much water is added, the water and solids will separate after mixing. If too much water is added on the initial trial, the mix should be discarded. A good starting point for the water is 350 liters per cubic meter (70 gallons per cubic yard). The batch volume of water would be:

$$\text{mL of water} = \text{sand mass} \times \frac{(350\,\text{L/m}^3)}{1550\,\text{kg/m}^3}$$

$$\text{mL of water} = \text{sand weight} \times \frac{(70\,\text{gal./yd.}^3)(8.34\,\text{lb./gal.})}{2600\,\text{lb./yd.}^3}$$

   2.   Record the amount of water added. Run the flow test as per I.M. 375 to obtain the efflux time.

3.   If the time of efflux is too long, increase the amount of water, air-entraining agent, or fly ash to improve the flow on the second trial. If additional water causes separation of the water and solids, fly ash should be added in 60-kg (100 lb.) increments up to a total of 240 kg per cubic meter (400 pounds per cubic yard). Air-entraining agent should be added in 19.35-mL (0.5 oz.) increments up to a total of 77.4 mL/m³ (2 oz./cu.yd.). Some sands will not produce satisfactory mix and will need to be rejected.

E.   Calculations and Reporting

1.   Determine the final mix design weights as follows:

$$\text{Fly Ash Mass} = \frac{\text{(grams fly ash used)}}{\text{(grams sand)}} \times 1550\,\text{kg/m}^3$$

$$\text{Fly Ash Weight} = \frac{\text{(grams fly ash used)}}{\text{(grams sand)}} \times 2600\,\text{lb./yd.}^3$$

$$\text{Water (Liter)} = \frac{\text{(mL water used)}}{\text{(grams sand)}} \times \frac{1550\,\text{kg/m}^3}{1\,\text{kg/L}}$$

$$\textit{Water} \text{ (Gallons)} = \frac{\text{(mL water used)}}{\text{(grams sand)}} \times \frac{(2600\,\text{lb./yd.}^3)}{(8.34\,\text{lb./gal.})}$$

Portland Cement = 60 kg (100 lb.)   Sand = 1560 kg (2600 lb.)

Air-Entraining Agent #mL/m³ (# oz./cu. yd.)

2.   Report the time of efflux to the nearest 1 second. The test report should be issued like the report in the Appendix.

EXAMPLE:

IOWA DEPARTMENT OF TRANSPORTATION
NWITC - Materials Laboratory
Test Report - SAND
Sioux City, Iowa

MATERIAL: 1-4110 sand

INTENDED USE: Flowable Mortar

LAB NO.: 3FM6-3002

DATE REPORTED: 10/28/96

SOURCE: Higman's Sand & Gravel, Akron

QUANTITY: 30 cubic meters

COUNTY: Plymouth

PROJECT: STPN-12-2(13)–2J-75

DESIGN: —

CONTRACT: 73512

PRODUCER: Joe's Ready Mix

CONTRACTOR: Brower Construction.

UNIT OF MATERIAL: 75# sack
Use with LaFarge Portland Cement with Midwest Fly Ash Port Neal #4

SAMPLED BY: C. Fenceroy SENDER'S NO. CF10-24-96-5   DATE SAMPLED: 10/24/96 DATE REC'D: 10/24/96

Sieve Analysis	%
3/8	100
#4	99
#8	88
#16	65
#30	35
#50	11
#100	1.3
#20	0.7

CC: Materials - Ames, Geology, R. Kalsem, C. Narotam, Proj. Engineer, Contractor, Source, Producer,
Lab, Proj. File

Disposition: Complies only with the following proportions: 100 lbs. cement, 300 lbs. fly ash, 2600 lbs.
sand. Flowability obtained in 15.9 seconds with 66 yd3 H2O

SIGNED: _____
C. E. Leonard, NWITC Materials Engineer